U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Materials Technology Program Overview

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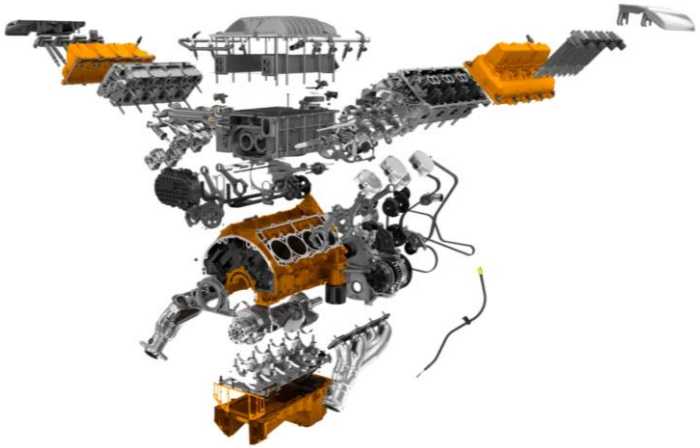
Materials Technology Program

Lightweight Materials enable an improvement in fuel economy through vehicle mass reduction.

Research areas include:
- Sheet Metals (Al, AHSS, Mg)
- Carbon Fiber Composites
- Multi-Material Joining

Propulsion Materials enable an improvement in fuel economy through increased engine efficiency.

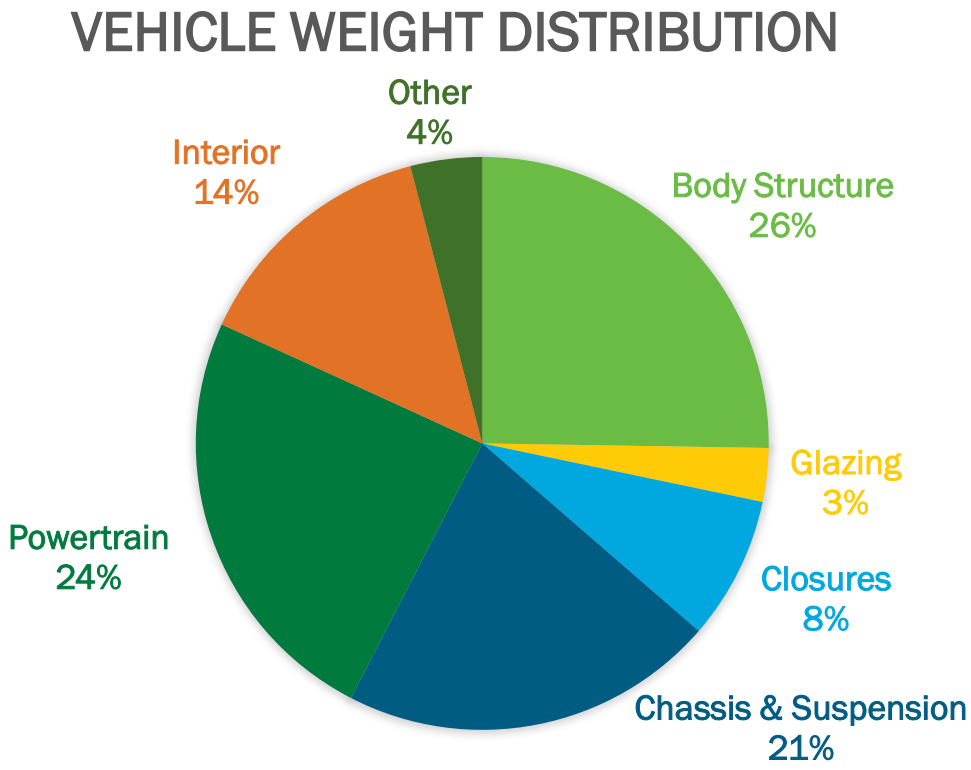
Research areas include:
- Cast Metals (Al, Cast Iron, Stainless Steel)
- High Temperature Alloys (500^{o} – 1100^{o} C)



Program Goals: 25% glider weight reduction at less than $5 / lb-saved and 25% improvement in high temperature component strength by 2025.

Program Focus Areas

The Materials Technology Program focuses on enabling materials solutions in two areas: the glider and the powertrain materials.



- **Reducing the weight of an internal combustion engine (ICE) vehicle by 10% can improve fuel economy by between 6% and 8%.**
- **A 13% improvement in freight efficiency can be achieved from a 6% reduction in vehicle weight when the reduced structural weight is replaced by cargo.**

Materials Technology Roadmap (October 2017)

Materials Challenges

Increasing Need for R&D

Increasing Impact on Reducing Vehicle Mass

Material	Critical Challenges				
Multi-Material Systems Enablers	High Volume Joining (Fusion, Mechanical, Adhesives)	Engineered Surfaces (Corrosion, Wear, Friction)	Predictive Modeling	NDE & Life Monitoring	Recycling
Carbon-Fiber Composites	Low-cost High-Volume Manufacturing	Low-Cost Fibers	Predictive Modeling	Joining, NDE, Life Monitoring & Repair	Recycling (OFFAL / Vehicle)
Aluminum	Low-cost Al Manufacturing Processes	Improved Alloys (Body/Powertrain) for Performance & Manufacturing	Joining Mixed Al Products	Recycling Vehicle	
Ultra High-Strength Steels	Improved Alloys for Room Temp Forming	Weldability for Dissimilar Steel Alloys	Predictive Modeling (Formability, Crash)		
Magnesium	Low Cost Feedstock, Low Carbon Footprint Production	Galvanic Corrosion Protection	Improved Alloys for Energy Absorption	Manufacturing (Sheet and Extrusions)	Recycling
Glazings	Low Cost Feedstock for Polymer Glazings	Low Temp Processed Chemically Toughened Glass	Durable, Scratch Resistant, UV Resistant Coatings		
Metal / Ceramic Composites	Feedstock Cost	Compositing Methods	Powder Handling	Compaction	Machining & Forming

Budget – Past and Present

- Lightweight Materials – This subprogram is focused on 1) Properties and Manufacturing, 2) Multi-Material Enabling, and 3) Modeling and Computational Materials Science

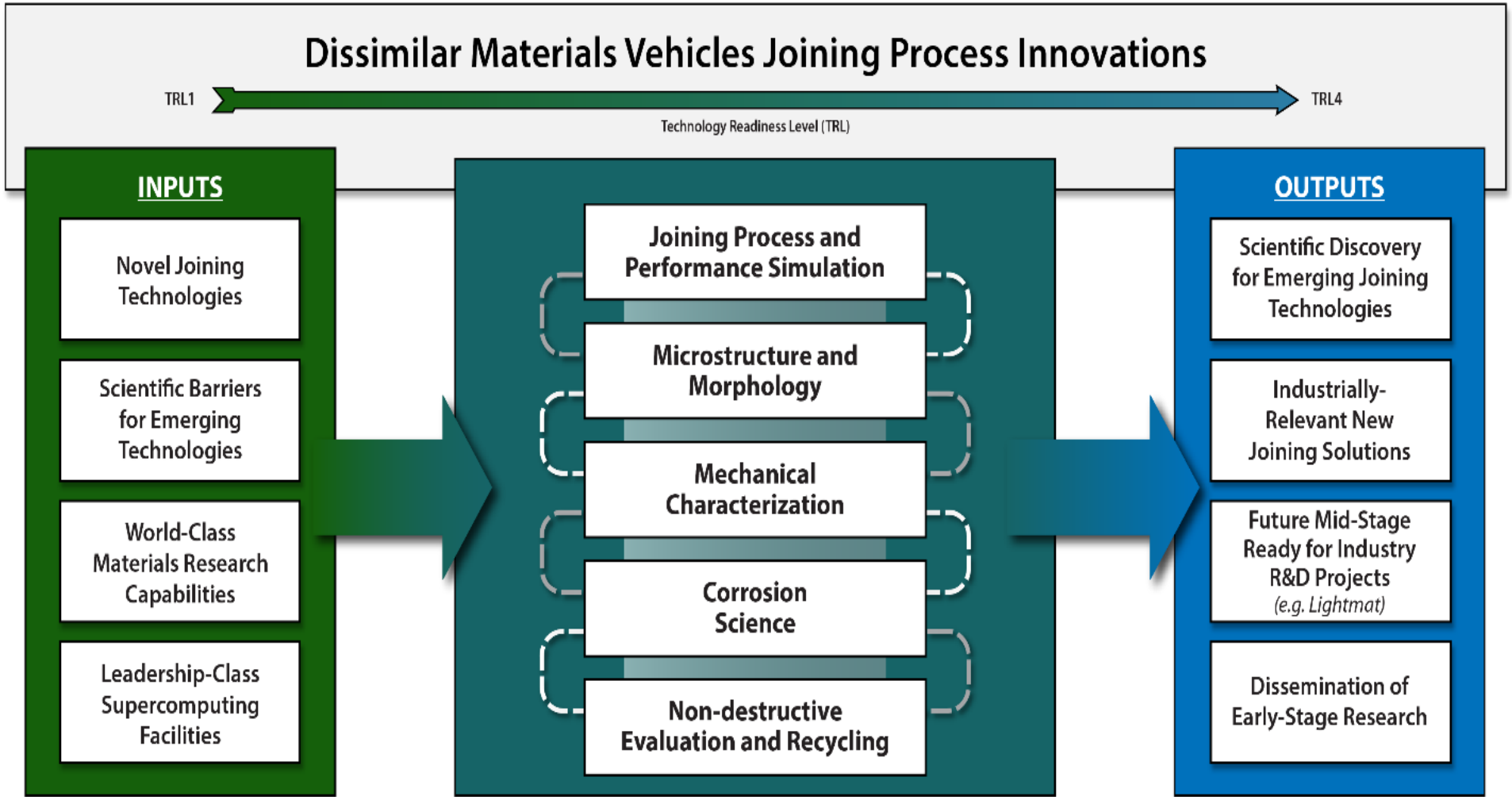
- Propulsion Materials – This subprogram is focused on 1) Engine Materials, Cast Al and Fe High Temperature Alloys and 2) Integrated Computational Materials Engineering

Funding in millions	FY 2017 Enacted	FY 2018 Enacted
Materials Technology	$28.1	$25.0
Lightweight Materials	$22.4	$15.1
Propulsion Materials	$5.7	$9.9

Joining Core Program

Advanced Joining Consortium to Enable Multi-Material Vehicles

Conducting Early-Stage Research and Development to Advance High-Volume Manufacturing Process Technology



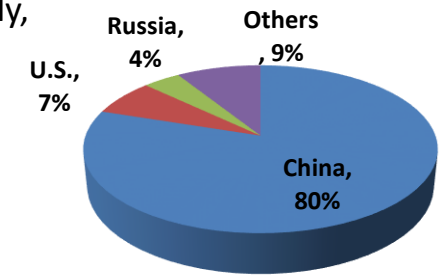
Four Materials with Highest Impact on Weight Reduction

Magnesium Alloys

Could achieve up to 40-70% weight reduction

Challenges: *Cost (~$3-10/lb-saved)*

- Lack of domestic supply, unstable pricing
- Corrosion behavior
- Inadequate strength, stiffness, and ductility
- Difficult to model deformation behavior



Aluminum Alloys

Could achieve up to 25-55% weight reduction

Challenges: *Cost (~$2-8/lb-saved)*

- Insufficient strength in conventional automotive alloys
- Limited room temperature formability in conventional automotive alloys
- Difficult to join / integrate to incumbent steel structures

Carbon Fiber Composites

Could achieve up to 60-70% weight reduction

Challenges: *Cost (~$5-15/lb-saved)*

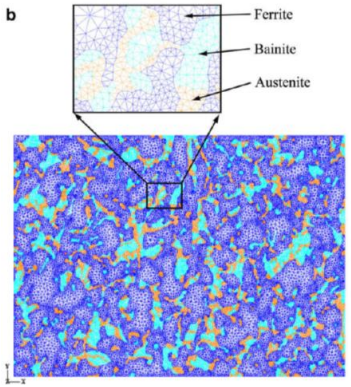
- High cost of carbon fiber
- High volume manufacturing
- How to join dissimilar materials
- Difficult to model across many relevant length scales due to fiber anisotropy

Advanced High Strength Steel

Could achieve up to 15-25% weight reduction

Challenges:

- Inadequate structure/properties understanding to propose steels with 3GAHSS properties
- Insufficient post-processing technology/understanding.
- What other relevant properties should be considered?
- Hydrogen embrittlement, local fracture, etc.

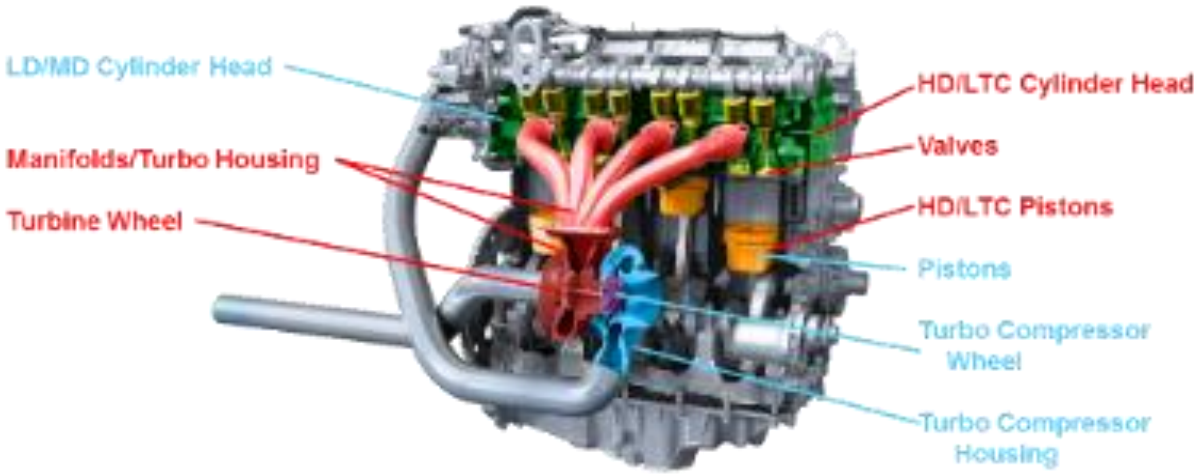


Choi et. al., Acta Mat. **57** (2009) 2592-2604

Powertrain Materials

Goals / Challenges

- Enable the development of new alloys with resistance to high temperature (500°C – 1100°C) corrosion/oxidation for components operating in the combustion chamber & exhaust system
- The efficiency of current engine designs is limited by the lack of low cost materials with enhanced high temperature performance for critical high temperature engine components



Areas of Future Research

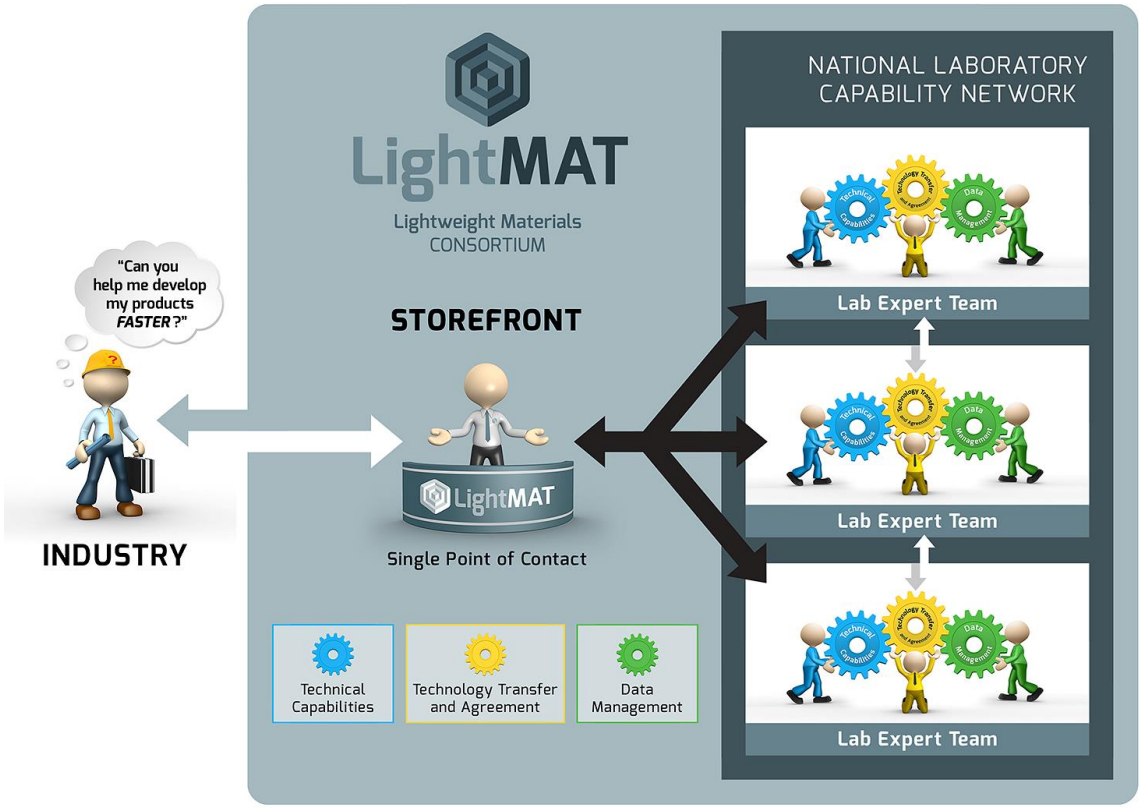
Enable weight reductions and efficiency improvements over a wide range of vehicle classes (HD-Heavy duty, MD-Medium Duty, LD- Light Duty) by addressing the high temperature materials needs of advanced engine design components.

- Research to develop high temperature >200°C & <550°C lightweight alloys for components shown in blue text above
- Research to develop higher temperature >550°C (Ni-, Fe-based) alloys for components shown in red text above
- Exploratory research in advanced processing techniques such as additive manufacturing, multi-material hybrid processes, and structured MMCs
- Accelerate materials development utilizing laboratory core capabilities in advanced materials characterization, synthesis, and modeling using high performance computing
- 50/50 cost shared industry CRADAs to advance early materials technologies to near application readiness

Energy Materials Network: LightMAT

Facilitating connections between industry and the National Labs by:

- Building a network of **unique National Lab resources**
- Providing a **single point of contact** and concierge
- Managing materials **data and tools**
- **Streamlining** the agreements process



http://LightMAT.org

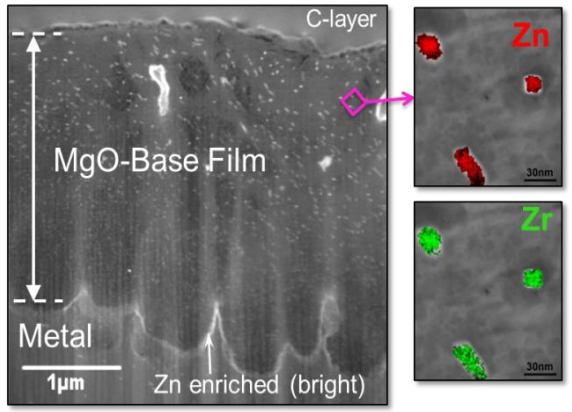
Lightweight Automotive Materials Consortium

LightMAT
Lightweight Materials Consortium

Ames Laboratory · Lawrence Livermore National Laboratory · NREL · Argonne National Laboratory · Los Alamos National Laboratory · Oak Ridge National Laboratory · INL Idaho National Laboratory · NETL · Pacific Northwest National Laboratory · Berkeley Lab · Sandia National Laboratories

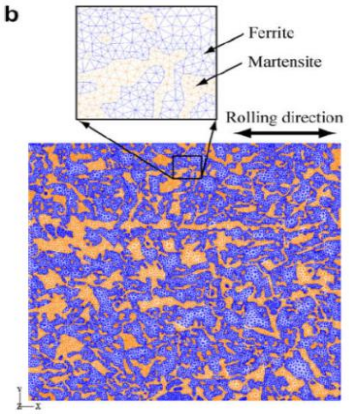
- **Connects the automotive industry with National Laboratory resources to facilitate lightweight materials research**
  - **Directed Funding Assistance Awards**
  - **FOA Awards**
  - **Work for Other Agreements**
- **Consortium of 11 National Laboratories with > 120 unique capabilities in materials characterization, computational tools, and manufacturing**

Characterization



Source: ORNL

Computational Tools



Source: PNNL

Processing / Manufacturing

Source: PNNL

www.LightMAT.org

Materials R&D Program - Funding Sources

- **Primary Funding Sources:**
  - Funding Opportunity Announcements (FOAs)
    - Solicitation for specific technology topic areas
  - Annual Operating Plans (AOPs)
    - Standard performance agreement between EERE and the National Laboratories
  - LightMAT Directed Funding Assistance Program
    - Industry users approach LightMAT (or vice versa) and develop project plan with concierge at no cost
  - High Performance Computing (HPC) for Manufacturing
    - Leverage the vast HPC capabilities at the national laboratories to partner with industry and address critical challenges
  - High Performance Computing (HPC) for Materials
    - Design to enable a step change in the cost, development time, and performance of materials

- **Secondary Funding Sources:**
  - Small Business Innovation Research (SBIR)
  - Small Business Voucher (SBV)
  - Technology Commercialization Fund (TCF)

$2.5 Million in LightMAT Funding Available

Directed Funding Assistance

- Application period will open on June 20th, 2018

Project Scope

- DOE awards up to $500,000; industry matches with cash or in-kind
- Project duration less than or equal to two years

Applications due

- July 31, 2018

LightMAT Labs will be showcasing their capabilities at the Tuesday night Poster Session

Note: White paper template and criteria available at http://LightMAT.org or by contacting the LightMAT Concierge

HPC4Mfg leverages National Labs' vast HPC capabilities to partner with industry and address critical challenges

- DOE labs possess 4 of the top 10 High Performance Computing (HPC) systems worldwide and broad expertise in their application and dedicated teams of expert practitioners
- Some larger companies use HPC, but struggle to stay current – few small to medium companies use HPC
- Challenges exist to Industry / National Lab partnerships

Source: ORNL

Source: NERSC

Source: LLNL

This program introduces the power of HPC to U.S. companies at low risk

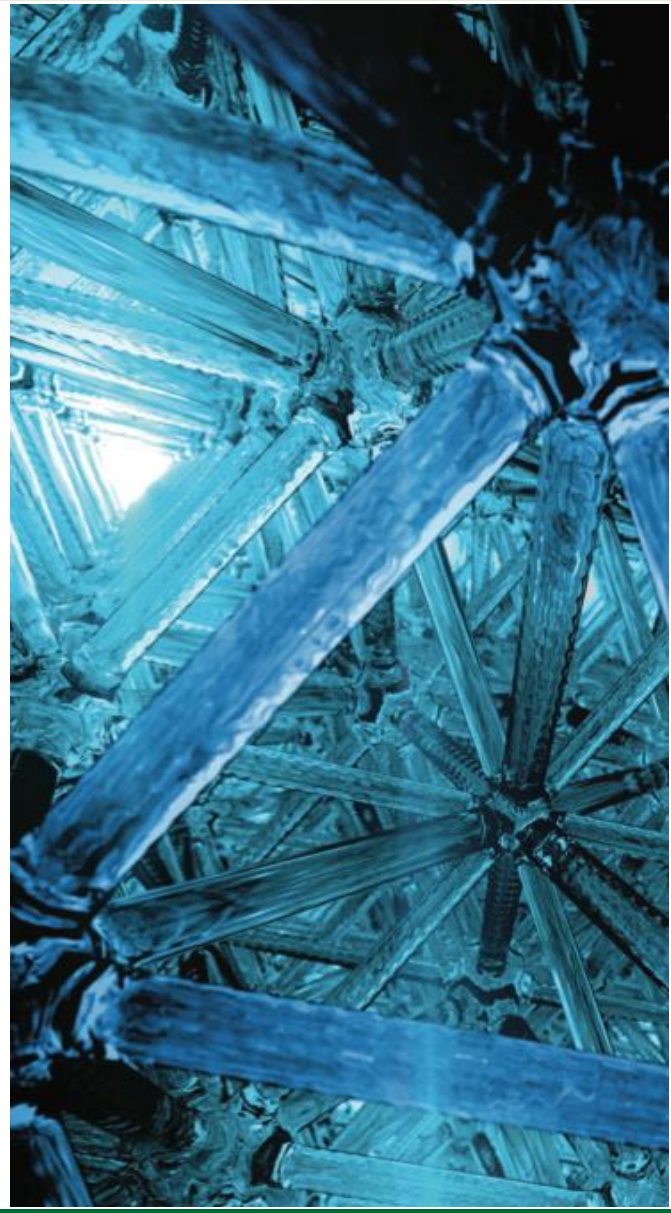
BERKELEY LAB
Bringing Science Solutions to the World

Lawrence Livermore National Laboratory

OAK RIDGE National Laboratory

Benefits of HPC to U.S. Industry

- Accelerate innovation
- Lower energy costs
- Reduce testing cycles
- Reduce waste/reduce rejected parts
- Quality processes and pre-qualify
- Optimize design
- Shorten the time to market

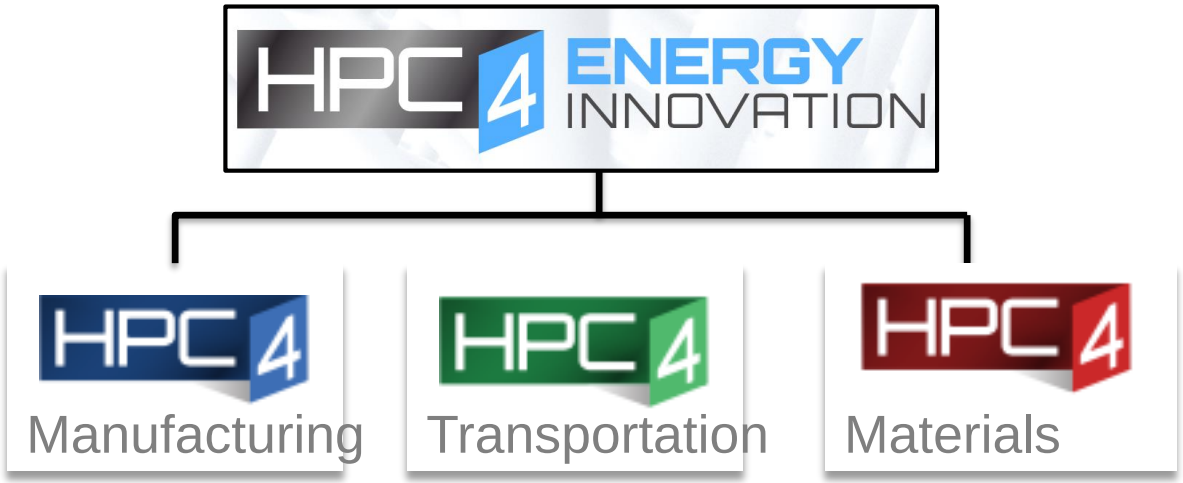


Enhances U.S. economic competitiveness; creates quality manufacturing jobs

HPC4Mfg infrastructure was designed for expansion

Other DOE offices are interested in leveraging the program for their missions

- Execute projects under current infrastructure or stand up “franchise” programs to support other offices
- Expand DOE partner labs



Leverage established infrastructure for savings and industry recognition

Execute within the industry sector on behalf of DOE mission

New methods of transportation, new fuels, tech explosion, etc.

Materials, extreme conditions, severe operating environments

Contacts

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https://energy.gov/eere/vehicles/vehicle-technologies-office-lightweight-materials-cars-and-trucks